

WHAT IS CLAIMED IS:

1. A method for performing an ultrasonic volumetric inspection of a test material, comprising the steps of:
 - providing a two-dimensional ultrasonic phased array, the phased array includes a plurality of ultrasonic elements arranged in a two-dimensional rectilinear grid pattern extending in an azimuthal and elevational direction;
 - applying modulation to each of the ultrasonic elements to form an ultrasonic scanning beam; and
 - interrogating at least a portion of the test material with the ultrasonic scanning beam.
2. The method according to claim 1, wherein each ultrasonic element is manipulatable to direct the ultrasonic scanning beam in at least one of the azimuthal and elevational directions to produce focal zones in at least one of an azimuth-depth plane and an elevational-depth plane.
3. The method according to claim 1, wherein the ultrasonic elements are transducers.
4. The method according to claim 1, further comprising the step of:
 - manipulating the ultrasonic elements in at least one of the azimuthal and elevational directions to produce focal zones at various levels of the test material.
5. The method according to claim 1, further comprising the step of providing at least one focusing lens in operative association with the ultrasonic elements.
6. The method according to claim 5, wherein the focusing lenses are one of concave, convex, linear and plano-concave.
7. The method according to claim 1, wherein at least one of the ultrasonic elements is capable of emitting a divergent ultrasonic beam.

8. The method according to claim 7, further comprising the step of forming discrete divergent ultrasonic scanning beams in the azimuthal and elevational directions.

9. The method according to claim 8, further comprising the step of forming the discrete divergent ultrasonic scanning beams in an azimuth-depth plane.

10. The method according to claim 8, further comprising the step of forming the discrete divergent ultrasonic scanning beams in an elevation-depth plane.

11. The method according to claim 1, wherein each ultrasonic element includes an aperture and wherein the method further comprises the step of independently adjusting the aperture of selected ultrasonic elements in two-dimensions.

12. The method according to claim 5, further comprising the step of focusing selected ultrasonic elements in two-dimensions.

13. The method according to claim 1, wherein the step of interrogating at least a portion of the test material includes taking a sequence of shots to produce a uniform beam sound field.

14. The method according to claim 1, further comprising the step of manipulating the ultrasonic scanning beam in azimuth, elevation and depth directions to produce at least one of a uniform and specific scanning beam for every point inside a volume of the test material.

15. The method according to claim 14, wherein the step of manipulating is accomplished electronically.

16. The method according to claim 1, wherein the two-dimensional phased array includes aperture control.

17. The method according to claim 16, wherein the aperture control provides control of an aperture of the two-dimensional phased array in at least one of

the azimuth and elevational directions to provide at least one of a uniform and specific scanning beam at every point inside a volume of the test material.

18. A two-dimensional ultrasonic phased array for inspecting a test material, the two-dimensional phased array, comprising:

a plurality of ultrasonic elements arranged in a two-dimensional rectilinear grid pattern extending in an azimuthal and elevational direction, each ultrasonic element is individually addressable and controllable to manipulate the formation of an ultrasonic scanning beam in both the azimuthal and elevational directions and to produce focal characteristics throughout the volume of the test material.

19. The two-dimensional ultrasonic phased array of claim 18, wherein the ultrasonic elements are transducers.

20. The two-dimensional ultrasonic phased array of claim 18, wherein the ultrasonic elements produce focal zones at various levels in an azimuth-depth plane.

21. The two-dimensional ultrasonic phased array of claim 20, wherein the ultrasonic elements produce focal zones at various levels in an elevation-depth plane.

22. The two-dimensional ultrasonic phased array of claim 18, wherein a selected number of ultrasonic elements define an aperture.

23. The two-dimensional ultrasonic phased array of claim 22, wherein the ultrasonic elements selected define a shape for the aperture.

24. The two-dimensional ultrasonic phased array of claim 23, wherein the aperture has at least one of a rectangular, a square, a circular, a semi-circular, an ovular, a triangular, a trapezoidal and a rhombular shape.

25. The two-dimensional ultrasonic phased array of claim 18, wherein the ultrasonic elements have a dimension in the azimuthal direction of about 0.5 to about 7 acoustic wavelengths.

26. The two-dimensional ultrasonic phased array of claim 25, wherein the ultrasonic elements have a dimension in the elevation direction of about 0.5 to about 20 acoustic wavelengths.

27. The two-dimensional ultrasonic phased array of claim 18, wherein each ultrasonic element is configured to emit a divergent ultrasonic scanning beam.

28. The two-dimensional ultrasonic phased array of claim 27, wherein discrete divergent ultrasonic scanning beams are formed in the azimuthal and the elevational directions.

29. The two-dimensional ultrasonic phased array of claim 28, wherein discrete divergent ultrasonic scanning beams are formed in an azimuth-depth plane.

30. The two-dimensional ultrasonic phased array of claim 29, wherein the discrete divergent ultrasonic scanning beams formed in the azimuth-depth plane define focal zones in the azimuth-depth plane.

31. The two-dimensional ultrasonic phased array of claim 30, wherein discrete divergent ultrasonic scanning beams are formed in an elevation-depth plane.

32. The two-dimensional ultrasonic phased array of claim 31, wherein the discrete divergent ultrasonic scanning beams formed in the elevation-depth plane define focal zones in the elevation-depth plane.

33. The two-dimensional ultrasonic phased array of claim 18, wherein the ultrasonic elements are placed symmetrically about a central axis of the array extending in the azimuthal direction.

34. The two-dimensional ultrasonic phased array of claim 18, further comprising a focusing lens oriented in the elevational direction and operatively associated with at least one ultrasonic element.

35. The two-dimensional ultrasonic phased array of claim 34, wherein the focusing lens is one of concave, convex, linear and plano-concave.

36. The two-dimensional ultrasonic phased array of claim 34, wherein the focusing lens is configured and dimensioned to produce one of a constant, an increasing and a decreasing F/D ratio over the operating range of the array.

37. A two-dimensional ultrasonic phased array for inspecting a test material, the two-dimensional phased array, comprising:

a rectilinear array of ultrasonic elements extending in an azimuth and an elevation direction, wherein each ultrasonic element is configured to emit a divergent ultrasonic scanning beam which divergent ultrasonic scanning beams combine to form a single ultrasonic scanning beam, wherein the divergent ultrasonic scanning beams formed in an azimuth-depth plane define multiple focal zones in the azimuth-depth plane and wherein divergent ultrasonic scanning beams formed in an elevation-depth plane define multiple focal zones in the elevation-depth plane.

38. The two-dimensional ultrasonic phased array of claim 37, wherein the ultrasonic elements are transducers.

39. The two-dimensional ultrasonic phased array of claim 37, wherein the ultrasonic elements have a dimension in the azimuthal direction of about 0.5 to about 7 acoustic wavelengths.

40. The two-dimensional ultrasonic phased array of claim 39, wherein the ultrasonic elements have a dimension in the elevation direction of about 0.5 to about 20 acoustic wavelengths.

41. The two-dimensional ultrasonic phased array of claim 37, further comprising a focusing lens oriented in the elevational direction and operatively associated with at least one ultrasonic element.

42. The two-dimensional ultrasonic phased array of claim 41, wherein the focusing lens is configured and dimensioned to produce one of a constant, an increasing and a decreasing F/D ratio over the operating range of the array.